Weatherwise

Squall Lines

Snow Eaters of the High Plains

American Meteorological Society

Favorable Spring Frost Conditions in the Middle Atlantic States

The Mild and Snowy Winter of 1951-52

Vol. 5, No. 2
APRIL, 1952

"SOME PEOPLE ARE WEATHERWISE BUT MOST ARE OTHERWISE"—BENJAMIN FRANKLIN

WEATHERWISE

THE MAGAZINE ABOUT WEATHER

DAVID M. LUDLUM, *Managing Editor* — CHARLES A. FEDERER, JR., *Editor*
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Automatic Weather Stations

A CLOSE WATCH on the activities of the Aleutian low is now being maintained by a robot-controlled weather station of the type pictured on the front cover. Amchitka, a bleak outpost in the Rat Islands of the Aleutian chain, was occupied in World War II and a fully manned weather station was set in operation. Though the island is of strategic importance in the present air route to the Orient, it was deemed inadvisable to maintain the five trained weathermen plus supporting personnel, due to the difficulties of supply and morale.

Accordingly, the Air Weather Service directed the Signal Corps Engineering Laboratory to design an automatic weather station that would eventually operate for a 12-month period without attention in a locality where temperatures might dip to −60° F. and wind speeds reach 100 miles an hour. A prototype was installed on Mt. Washington in 1950 and the first test model was placed on Amchitka Island last year.

Automatic weather stations were under development during World War II, but were not perfected in time to be of real service. The Germans, however, made use of several types of automatic reporting stations, though intelligence reports say the Luftwaffe did not consider them sufficiently dependable. For the past six years, the U. S. Weather Bureau has maintained modified types of the war models on the islands of Orange Cay and Dog Rocks in the Bahamas and at Flamingo on the southwestern tip of the Florida peninsula, as part of the Hurricane Warning Service.

Early this year the Bureau of Standards announced the completion of a floating automatic weather station for the U. S. Navy that can be used in out-of-the-way places and also placed in enemy-held waters. All three weather services, the Weather Bureau, Air Force, and Navy, have announced plans for the greater use of automatic stations. The technical details of these stations will be the subject of a future article in WEATHERWISE.

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Cover: A U. S. Army Signal Corps automatic weather station during tests under severe winter conditions on Mt. Washington, New Hampshire. This type of station, in the Aleutians, reports to an Air Weather station 250 miles away, giving by radio in Morse code the rainfall, sunshine, wind speed and direction, pressure, humidity, and temperature. U. S. Army photograph. (See the article on this page.)

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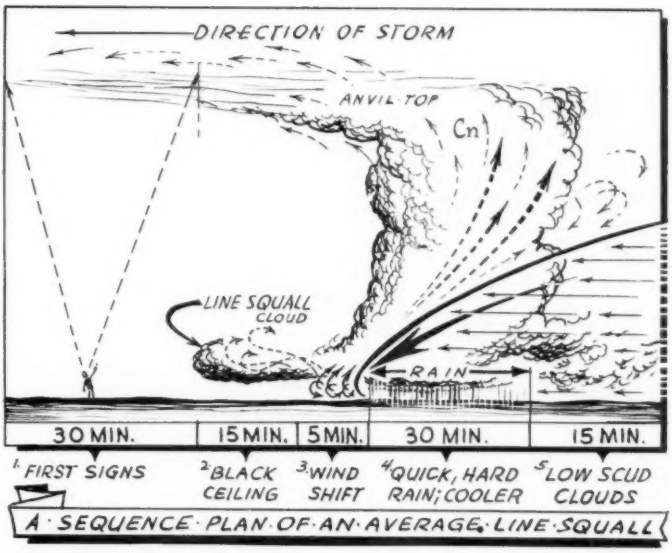
Squall Lines

IVAN W. BRUNK

U.S. WEATHER BUREAU
CHICAGO, ILLINOIS



A cross-section drawing by Eric Sloane shows the development of a line squall and the turbulence associated with it.

AMONG THE MOST INTERESTING but least understood of weather phenomena is the *squall line*. This term is currently in popular use by pilots, aviation forecasters, and many meteorologists to describe weather typical of a cold front, but which is generally found some distance in advance of the cold front. More recently, the term *instability line* has come into official use by international agreement to describe this phenomenon — the prefrontal squall line — but those words are less descriptive, especially from the point of view of the pilot.

While most squall lines develop in advance of cold fronts, they may also occur north of warm fronts, north of frontal wave crests, and even in the vicinity of cold fronts. In the last instance, they may at first be confused with the front itself, but within a few hours a true squall line moves out in advance of the front and displays the usual characteristics.

Most of this article is based on studies by the author during the past 10 years of this phenomenon in the Middle West. Lately, several theories have been proposed to explain squall-line formation, but this aspect of the subject is beyond the scope of this article. In the *Journal of Meteorology* for February, 1950, Morris Tepper describes "A Proposed Mechanism of Squall Lines: The Pressure Jump Line," and in the June, 1950, issue, C. W. Newton describes the "Structure and Mechanism of the Prefrontal Squall Line."

The weather along a squall line is characterized by thunderstorms, heavy rain, brief wind shifts, gusty winds, abrupt pressure rises, and sharp temperature falls. The zone of activity is usually parallel or nearly parallel to a surface cold front, but squall lines may develop in other locations. Surface winds in advance of the line are usually southerly, shifting almost instantaneously to a westerly or northerly direction at the onset of the phenomenon.

The speed of the wind observed with the wind shift is extremely variable from station to station. It is usually between 20 and 40 miles per hour, but may occasionally be much higher. Heavy rain frequently occurs, but sometimes the wind-shift line will be found far in advance of the thunderstorm activity or rain. The duration also varies from station to station, but usually 45 minutes or so after the squall-line passage, conditions are nearly the same as before its arrival.

Because of their short duration, squall lines are not readily identifiable on the usual synoptic maps drawn at times of their occurrence. Sometimes they form in a small region and then fan out over a relatively large area. Occasionally, more than one

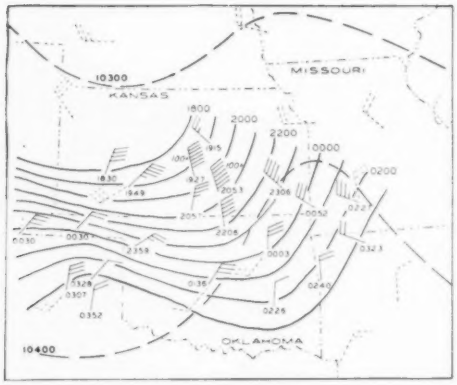


Fig. 1. Hourly movement of the squall line of July 14-15, 1948. The time is Central standard; dashed lines are 700-mb contours, and the winds are plotted for 2100 CST on the 14th.

squall line can be identified at the same time in the same general locality, each moving in a different direction. Except at lower levels, as indicated by the surface wind, their direction of movement does not appear to have a direct relationship to the wind at any level; the direction of the strongest surface wind is usually that from which the squall line is moving.

Instability lines may occur in any month of the year, but they are much less frequent in winter than during the thunderstorm season, with their greatest frequency in the late spring and the summer months. Most squall lines form in the late forenoon, but they may occur at any time during day or night. The area of development and the time of greatest frequency correspond closely to these factors for tornadoes.

To a local observer, the awe-inspiring effects of a local thunderstorm cannot usually be distinguished from a squall-line thunderstorm. A dense network of reporting stations is necessary to identify and follow the movement of squall lines. Because of their brief duration at any one place, close attention must be given to all hourly and special observations, or some squall lines will be missed. It is sometimes necessary to draw hourly maps to locate them. The more extensive use of radar will also be an important aid.

Surface wind information is considered by this author to be the best available synoptic indicator of the movement of a squall line. Of most significance is the surface wind shift attending the line of thunderstorms which constitute the squall line. Its formation is usually first indicated when two or more stations in the same general area report thunderstorms with pronounced wind shifts and pressure rises. The progress of the squall line is followed by plotting the time of wind shift and the direction and velocity of the highest wind on a section of a blank base map with a scale of 1:5,000,000. After a number of reports have been plotted, isochrones or lines of equal arrival time can be drawn to show the hourly movement of the squall line. This is usually rather uniform, with an average speed of around 40 miles per hour, but in some cases the apparent advance may be as much as 60 miles per hour or more.

An example of the analysis by the wind-shift method is shown in Fig. 1, for an unusually severe squall line that occurred on July 14-15, 1948. Damage to crops and property was approximately nine million dollars, which is more than the total damage in many a hurricane. Winds at both Wichita and Hutchinson, Kansas, exceeded 100 miles per hour.

Because of its short duration at any station, the pressure rise attending the passage of a squall line may not show on synoptic maps drawn at the time. In some cases, however, the pressure rise is sufficient to appear in the analysis of a regular synoptic map. The example in Fig. 2 shows a high suffi-

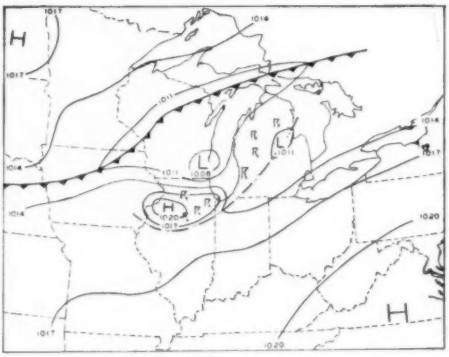


Fig. 2. A section of the weather map for July 27, 1947, at 0330 CST.

A line squall cloud preceding a cold front near Lincoln, Nebraska, June 10, 1936. The clouds were moving from the northwest. The squall line was approximately 300 feet in diameter and 100 to 150 feet above the ground. USWB photograph by John C. Hagen.

ciently large to warrant drawing of several isobars around it. When large rises are shown on the surface map just to the rear of a squall line, the pressure may fall abruptly several hundred miles farther to the rear. This map shows a low of this type in southeastern Wisconsin, where Milwaukee reported a wind of 35 miles per hour from the southwest at about map time.

Unusual fluctuations in water level over a short period, called *seiches*, are sometimes associated with such barometric variations. These are occasionally observed on the Great Lakes; for instance, a seiche was reported on Lake Michigan in connection with the barometric and wind changes shown in Fig. 2.

Since some of the worst flying conditions that pilots encounter occur in the vicinities of squall lines, their identification and forecasting is important to aviation. Severe turbulence is sometimes difficult to avoid because squall-line thunderstorms frequently form a solid line several hundred miles long. Pilots generally penetrate squall lines at altitudes as low as practicable, because of the belief that turbulence is less severe in the lower levels, but this has not been definitely proven.

As a matter of fact, there is some indication that turbulence may be quite severe in the lower levels, as shown by the record of the flight of a DC-2 plane through a squall line at 2,000 feet above sea level between Washington, D. C., and Richmond, Virginia, on June 11, 1936. The pilot reported that the down gusts were of sufficient violence to throw a passenger out of his seat up toward the top of the cabin. Computations made from recording instruments in the plane show that the turbulence experienced was greater than that computed from the USWB Thunderstorm Project data for any elevation.

Severe turbulence is sometimes reported outside of the cloud and rain areas associ-

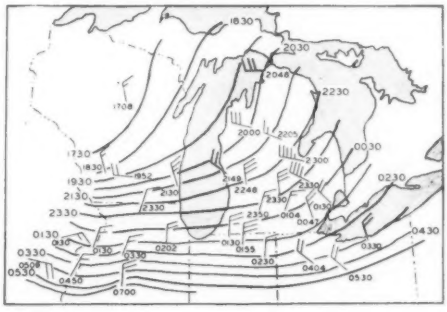


Fig. 3. Hourly movement of the squall line of June 23-24, 1950, shown in Central standard time. The time of wind shift and the surface winds at the approximate time of wind shift are indicated.

ated with squall lines. On June 13, 1950, a pilot reported extremely heavy turbulence in the clear in the vicinity of a squall line at 2,000 feet above sea level in southeastern Missouri. The nearest clouds were estimated to be five to 10 miles away. The pilot had flown the hump in China and the little hump in Alaska and stated that he had never encountered any rougher turbulence than in this instance.

The movement of a squall line on June 23-24, 1950, when one of the worst aviation disasters in the history of the United States occurred, is shown in Fig. 3. This does not imply that this squall line was more severe than any other, but its southern edge was at the approximate location of the accident at the time of its occurrence. The official investigation indicated that the disaster probably resulted from either a structural failure caused by the turbulence or because control of the airplane was lost. At least three other commercial airline accidents in recent years have been associated with squall lines, and others may have taken place under similar circumstances before the occurrence of instability lines was recognized.

The relationship between tornadoes and squall lines has aroused considerable interest among meteorologists. Both of these violent phenomena occur under similar synoptic conditions, and both are apparently parasites of thunderstorms. Tornadoes sometimes are found in connection with squall lines, but occur more frequently when there is no identifiable line of instability. The fact that tornadoes occur with cumulonimbus clouds, either of the squall-line or individual type, has been fairly well established. However, the exact mechanism of tornado formation and squall-line development will probably continue to be a source of speculation for many years to come.

GREAT LAKES SEASON OPENS EARLY

The Great Lakes shipping season made an earlier than normal start this year when the first ships moved from Detroit to Cleveland on March 11th. The key to the opening date of the lakes has been found to be the average temperature in February. This was four degrees above normal this year. The earliest opening date of the navigation season was March 1st — in 1890, 1932, and 1937. The latest date on record was April 19, 1881.

RAINMAKING SUITS DISMISSED

The deluge of damage suits that threatened to wash out $2,000,000 from New York's treasury was stemmed recently by a Supreme Court decision. Because of a technicality in drawing the papers, Justice Samuel H. Hofstadter dismissed more than 100 suits that had been brought by upstaters for alleged damages as a result of Dr. Wallace E. Howell's experiment in rainmaking in the Catskill area.

The court granted the city's contention that the summonses and complaints had not actually named the city as the defendant, but had named certain individuals who were either officials of the city or were members of the rainmaking team. A motion to amend the papers was disallowed. No further action against the city for damages can be taken, because a 13-month statute of limitations for damages against the city took effect in January.

PROJECT CIRRUS TO END

The investigation of cloud physics known as Project Cirrus has been carried on by the General Electric Company for the Signal Corps and the Office of Naval Research since 1947, a few months after the first discoveries of artificial cloud seeding were announced by Drs. Vincent Schaefer and Irving Langmuir. The project will be terminated on June 30, 1952, as it is felt its original objectives have been achieved.

A WEATHER STAMP

A bill to issue a commemorative postage stamp in honor of the Weather Bureau's cooperative observers was recently introduced into Congress by Representative J. Caleb Boggs, of Wilmington, Delaware. It would pay tribute to "the co-operative observers, whose voluntary services have constituted an outstanding contribution to the effective operation of the United States Weather Bureau." The bill was referred to the respective Senate and House postal committees.

Low Humidities in the Southwest

During the month of June, 1951, the relative humidities recorded at Las Vegas, Nevada, averaged much lower than those at Albuquerque, New Mexico, concerning which a report was published in **Weatherwise** for October, 1951 (page 114), by H. E. Hutchison, meteorologist of the Weather Bureau office at the latter place.

The reduction of data at Las Vegas was carried out by means of the Weather Bureau psychrometric calculator (WB form 1183C) for a barometric pressure of 28 inches of mercury, since the station elevation is 2,180 feet. No precipitation was observed at Las Vegas during June, 1951.

There were six days when the relative humidity dropped to three per cent or less, with a total of 31 hourly observations in this range during the month. On one entire day the humidity did not exceed eight per cent and on another, nine per cent (June 27th and 28th, respectively). A total of 318 hours out of 720 in the month (44 per cent of the time) had reported relative humidities of nine per cent or less.

The minimum and maximum reported values of relative humidity during the month were one per cent and 36 per cent, respectively, and the following listing shows that half of the hours had a humidity of 10.3 per cent or less, while one fifth of the hours had a humidity of 6.2 per cent or less. A smooth curve was constructed to yield the cumulated frequencies of hours during which relative humidities less than or equal to given amounts were observed (first figure, relative humidity; second figure, cumulated frequency, per cent of total hours): 1.9, 1%; 2.4, 2%; 3.8, 5%; 4.8, 10%; 6.2, 20%; 7.5, 30%; 8.9, 40%; 10.3, 50%; 12.2, 60%; 14.4, 70%; 16.8, 80%; 21.2, 90%; 36.0, 100%.

During the last seven days of the month the low humidity was unusually persistent. Thus, at 0828 PST, June 24, the humidity was 15 per cent. Until 2328 PST, June 30, it was mostly well below this value and only surpassed it on one hour, to 16 per cent. From 0628 PST, June 26, to 2328 PST, June 28, the humidity was nine per cent or less. Thus, the phenomenon occurred during the night in addition to the day, as pointed out by Mr. Hutchison.

To be sure that the reports of phenomenally low relative humidities, of say five per cent or less, should be given credence, one must examine the basis of the data. The dew-point temperatures and relative humidities have been evaluated with the aid of Ferrel's psychrometric equation (see Annual Report of the Chief Signal Officer, U. S. Army, 1886, Appendix 24). As a basis for judgment as to whether the formula is valid at extremely low relative humidities, some observations made under such conditions at Pomona and Beaumont, California, on January 3, 1949, have been examined. The conclusions of the investigation, which must be regarded as tentative at the present time, indicate that the aforementioned psychrometric formula is unreliable under these conditions, and that the dew points and humidities computed by means of the formula for cases of very low relative humidity require the application of some positive corrections. It is planned to report more fully regarding this at a later date.

L. P. HARRISON
Meteorologist, USWB
Washington, D. C.

ED. NOTE: Space does not permit inclusion of a table of detailed observational data for Las Vegas for June, 1951, sent with this note, but Mr. Harrison will undoubtedly supply it to qualified correspondents.

SPRING TORNADOES AND THE TORNADO WARNING SERVICE

Disaster struck the lower Mississippi Valley area on March 21, 1952, as a series of tornadoes swept Arkansas, Mississippi, Alabama, Tennessee, Kentucky, and Missouri. The death toll, according to early press reports, amounted to 225 persons, with over 1,000 seriously injured. Total damage is expected to exceed 10 million dollars, since several rural towns were almost completely leveled. It was the greatest tornado disaster ever to hit the state of Arkansas. The town of Judsonia, about 60 miles northeast of Little Rock, was described as looking as if "a giant steamroller had crushed everything in sight."

Spring is the season when the tornado funnel reaches its greatest fury, but such a death toll as occurred this year has not been equaled since 1932, when a series of twisters descended on Georgia. The all-time high for deaths occurred in the month of March, 1925, when 709 persons lost their lives in the gigantic tornado series that hit across Missouri, Illinois, and Indiana.

This year marked the first time that the U. S. Weather Bureau has officially issued warnings of the possibility of tornado occurrences. Warnings were dispatched on the morning of March 21st as a very active storm center was moving from Texas on a north-northeast track toward the Great Lakes. Exceptionally cold air for the season lay to the west, with below-zero temperatures, while a very moist, warm air mass occupied the Gulf states. The tornadoes, as predicted, occurred in the area just to the east of the cold front. Warnings were also issued on the 22nd for the middle South, and several small tornadoes were noted in Alabama and Tennessee that day.

The Weather Bureau's Tornado Warning Service is located in Washington, D. C., at the central office.

A typical chinook crest cloud over the Colorado Front Range. This boiling cloud mass, which extends to about 16,000 feet, conceals the serrate peaks and spires of the range. The formation of the crest cloud is shown in Fig. 2.

Snow Eaters of the High Plains

RONALD L. IVES, CORNELL AERONAUTICAL LABORATORY

SEVERAL TIMES EACH WINTER the high plains area lying to the east of the Rocky Mountains from Cheyenne, Wyoming, to Trinidad, Colorado, is swept by strong west winds. This downslope flow of air can raise the temperature many degrees in a few hours and can evaporate a deep snowcover. These winds are locally known as chinooks.

The record of a strong chinook is shown on the instrument charts in Fig. 1. Typical of these winds are the rapid rise of temperature and the rapid drop in relative humidity. Snow removal during such winds is by evaporation or sublimation — the direct transition from solid state to vapor without passing through a visible liquid phase. Thus, chinook winds in this area do not produce floods from snowmelt.

During a typical chinook, skies over the plains area are beautifully clear, but the mountain ranges to the windward are hidden in turbulent crest clouds, sometimes extending upward to 16,000 feet above sea level. In many instances, cumulus rolls and standing clouds are present over the leeward foothills, due probably to a "bounce" effect of strong winds on the uneven terrain. These cumulus rolls and standing clouds commonly retain their geographical position for many hours despite the rapid eastward flow of the air near the surface. These west winds sometimes exceed 50 miles per hour.

During the latter stages of a chinook wind, when most or all of the surface snow is gone, large quantities of dust may be moved; and static electricity disturbances, sometimes severe enough to stall automobiles and to disable communications, are occasionally reported. And in a few instances, ice has even been removed from ponds by a well-sustained chinook.

The changes of the weather elements during a chinook (Fig. 2) are in accord with the theories of thermodynamics that have been described by W. J. Humphreys in his *Physics of the Air*. When moist air is forced upward in crossing a mountain range, its temperature drops adiabatically, that is, be-

cause of reduction in pressure, at the rate of about 5.5° F. per 1,000 feet until it reaches the dew point. Then condensation takes place, and the adiabatic temperature drop is partially offset by the heat released as the water vapor condenses to liquid or solid water. The rate of the net temperature drop above the height of the condensation level will depend upon the amount of water vapor condensed, and will always be less than the adiabatic rate that prevailed below. The zone of condensation is clearly defined by the limits of the crest cloud on the windward side of the range. Some of the condensed water vapor may be carried over to the leeward by the wind, and some of the snow is commonly blown across the summit of the range.

As the air descends the leeward side of the range and is compressed, its temperature rises at the adiabatic rate, so that level for level the temperatures will be higher on the leeward side of the range than to the windward. Furthermore, both relative humidity and specific water content are low to the leeward because of loss of water in the ascent.

On the plains to the east of the Rockies, chinook air is warm and dry. Water in any form exposed to this wind will be evaporated quite rapidly. The evaporation process withdraws heat from chinook air at an appreciable rate and at the same time humidifies the air, so that the characteristic warmth and dryness of the chinook decline farther to the east. The increase in humidity is particularly marked when the chinook air passes

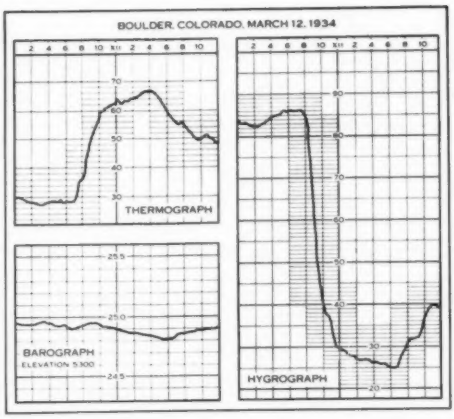


Fig. 1. Tracings of instrument records of temperature, pressure, and humidity at Boulder, Colorado, during the chinook wind of March 12, 1934.

over snow; but when it blows over dry land, the humidity remains low. This is clearly shown by the computed aqueous vapor pressure for Boulder, Colorado (Fig. 3), for the chinook condition recorded in Fig. 1. Here, although the relative humidity declines abruptly during the early part of the windstorm, the water content of the air increases with almost equal suddenness, then remains at a high level as long as snow is available for evaporation. As soon as the snow is gone, the air is no longer humidified, and the water vapor content declines sharply until the storm ends.

Although the mechanism of chinook winds is known, their prediction is still a difficult

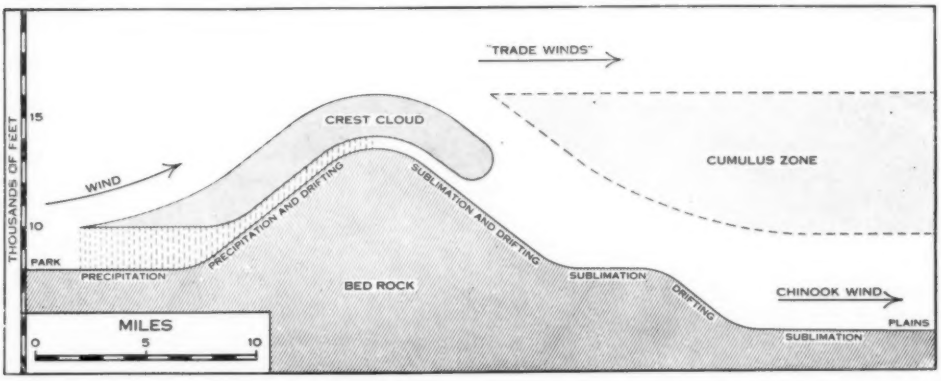


Fig. 2. This schematic diagram shows the sequence of meteorological events during the development and passage of a typical chinook wind.

problem, because of a lack of weather stations to the windward of the mountain ranges. A study of weather maps for those days on which chinook winds have occurred discloses that they are most common after a strong high has "camped" over southeastern Idaho for several days. This same condition may also produce "northers" in the area of the Gulf of California and dense fogs in the Great Valley of California. In some instances, all three occurrences have accompanied the overflowing of the same Great Basin high.

Whether, in crossing the Colorado Rockies, a west wind will become a chinook or merely a fallwind, exhibiting no particular warmth and dryness over the eastern slope, depends upon the humidity of the rising air. If the moisture content is sufficiently high, so that condensation takes place during the crossing of the range, the wind will be a chinook; otherwise, it will be merely a fallwind.

Strong vertical mixing commonly takes place over the jumbled topography of western Colorado, so that the air near the surface

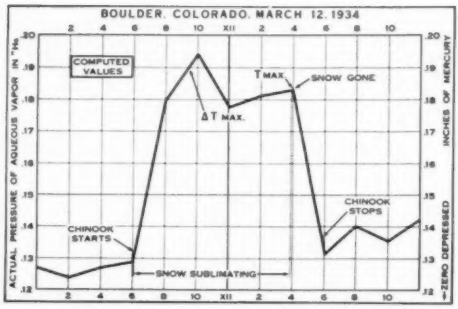


Fig. 3. Water vapor content of the air at Boulder, Colorado, during the chinook wind of March 12, 1934, as computed from the data of Fig. 1.

is often subject to considerable local modification. Therefore, forecasting of chinook winds, even when the pressure pattern is favorable for their development, cannot simply be based on humidity measurements at a strategic location to the windward, such as Grand Junction. Better results are, of course, obtained when adequate upper-air data are available.

Chinook-type winds are not confined to the Colorado high plains, but are also observed in other areas on the eastern side of the western mountains. For example, in some localities to the leeward of the California Sierras they are known as Washoe zephyrs. They occur in the Black Hills country, and occasionally in the eastern part of Utah. In Europe, similar winds are noted in the Alps, where they are called foehn winds. On the Argentine pampas a wind of similar origin is known as the zonda. Many other local names are in use throughout the world.

Standing clouds over foothills during a strong chinook.

AMERICAN METEOROLOGICAL SOCIETY

NOTES ON THE 114TH NATIONAL MEETING

OVER 500 members and friends of the American Meteorological Society attended the four-day 114th national meeting, at the Hotel Roosevelt in New York City on January 28-31, 1952. This annual fixture on the meteorological calendar was held, as usual, in conjunction with the meetings of the Institute of Aeronautical Sciences.

Forty-seven individual papers were presented. A special feature of the occasion was the exhibit of meteorological equipment sponsored by the Armed Forces and by various instrument manufacturers. A facsimile machine was again in operation, so that all weather watchers could keep up to date with current weather maps and analyses. The weather elements followed a familiar AMS pattern by putting on a snowstorm during the opening session, a coincidence that was not lost on the local press.

The main event of the meeting was the annual dinner of the society held on Wednesday evening, preceded by a cocktail party given by the Friez Instrument Division, Times Facsimile Corporation, and the Dewey and Almy Chemical Company, all of whom had booths with meteorological equipment on display.

The guest speaker of the evening was Dr. Alan T. Waterman, director of the National Science Foundation. Dr. Waterman related that he had been involved with the weather at an early age, having been a government meteorologist during World War I; thus, he could understand the trials and tribulations of the profession. He called attention to the great progress the science has made since his first acquaintance with it, and pointed out the manifold part that meteorological research will play in the activities of the National Science Foundation.

Dr. Waterman outlined the origin and growth of the idea of creating the foundation. For a considerable period, it was merely a plan on paper, but with the appropriation of $3,500,000 by Congress last year, the foundation is ready to go into action. The main objectives will be to develop a national science policy, to support research in basic sciences, and to encourage training through the award of graduate fellowships. Many research proposals have already been received, more, in fact, than current funds will support. No research centers of the National Science Foundation will be created, but emphasis will be put on stimulating small institutions and even individuals to engage in basic research in the sciences. There will be a minimum of red tape in the administration of the projects. Five hundred fellowships for the academic year 1952-53 will be announced shortly. Among the fields of interest to AMS members that will be considered in 1953 are upper-atmosphere physics and fluid mechanics.

At the annual business meeting, held the afternoon before the dinner, results of the recent elections were announced. The new president is Dr. Horace R. Byers, chairman of the department of meteorology at the University of Chicago. Col. Ben H. Holzman, National War College, U. S. Air Force, is vice-president. Dr. Charles F. Brooks, Harvard University, secretary, and Henry DeC. Ward, of Boston, treasurer, were reelected. The following members will join the council for a three-year term: E. Wendell Hewson, Massachusetts Institute of Technology; H. E. Landsberg, Air Force Cambridge Research Center; F. W. Reichelderfer, USWB; Vincent E. Schaefer, General Electric Research Laboratory; Edward M. Vernon, USWB.

Ice-protection systems, forecasting condensation trails for both gas and jet-type planes, and instances of clear-air turbulence were discussed at the joint meeting with the Institute of Aeronautical Sciences. But the main feature of the gathering was a paper by a visitor from abroad, A. C. Campbell Orde, operations development director, British Overseas Airways Corp., England, who spoke of his company's experience with the new jet commercial liner, Comet I.

Mr. Orde stated that the Comet I has flown over 600 hours on regular commercial routes between England and South Africa and England and Australia. He stressed the greatly increased significance of the weather forecast in the operation of such aircraft, since the

balance between pay load and fuel load is very delicate. Our forecasters in the military ranks have had considerable experience with jet flight techniques, but Mr. Orde pointed out that the economic factor of fuel consumption will be paramount in forecasting for commercial jets.

The Comet I on a typical flight climbs to an altitude of 32,000 feet in less than an hour after take-off. As the fuel load lessens, the craft climbs to a maximum cruising level of about 42,000 feet, where it operates with greatest efficiency. Temperature and wind have great effect on the speed at which the craft will fly. At take-off, a variation of 15° C. in temperature will make a pay-load difference of about 400 pounds, or two passengers, on a typical flight, and a 50-knot headwind will require an extra 2,000 pounds of fuel. Thus, an accurate forecast of these two elements must be available to the flight planner as well as to the pilot in flight.

Also of great importance is the weather condition at the prospective terminal. On a six-hour flight, the three-hour mark, of course, is the point of no return. At that time the pilot must be sure that his terminal will be open. At 4¾ hours elapsed time, he must either start a letdown to a predetermined alternate airport or must continue on to the terminal, certain that he can find it and that landing conditions will be favorable.

Mr. Orde suggested that an expanded global network of observing stations with devices for taking quick soundings of the upper air will be necessary, that much quicker means of communicating weather information from observer to pilot in flight must be developed, and that full international cooperation of all aeronautical people will be essential to safe operation of commercial jets.

Members and guests at the 114th national meeting of the American Meteo

AMS 115TH MEETING IN WASHINGTON, D.C.

The 115th national meeting of the American Meteorological Society will be held at Washington, D. C., May 6-9, 1952. The Washington Branch of the AMS will sponsor the meeting and is in charge of all local arrangements. Lt. Col. Robert Bundgaard, of the Air Weather Service, is chairman of the meeting.

Nine sessions of technical papers are scheduled on the following topics: May 6, morning, Symposium on Upper Atmosphere; afternoon, Cloud Physics; May 7, morning, Turbulence; afternoon, Symposium on Coordinating Meteorological Research and Weather Forecasting; May 8, morning, Synoptic and Dynamic Meteorology; afternoon (simultaneous sessions), Radiation and Instrumentation; May 9, morning, Synoptic and Dynamic Meteorology; afternoon, Weather Forecasting.

A banquet will be held at 7:45 p.m. on Wednesday evening, May 7th, at the Burlington Hotel, Vermont Avenue and Thomas Circle, and will be preceded by a cocktail party. The speaker of the evening will be Rear Admiral Calvin M. Bolster, USN, Chief of Naval Research. The annual presentation of the Meisinger award is scheduled for that evening.

Since the capacity of the dining facilities is limited to 200 persons, advance reservations should be made by mail to the chairman of the entertainment committee, Herbert S. Appleman, Headquarters, Air Weather Service, Washington 25, D. C. Reservations for hotel accommodations may be made by AMS members at the Burlington Hotel, but must be received by the room clerk prior to April 21st.

erican Meteorological Society, Hotel Roosevelt, New York City, January 30, 1952.

Favorable Spring Frost Conditions in the Middle Atlantic States

CHARLES B. JOHNSON, USWB DISTRICT FORECAST CENTER
WASHINGTON NATIONAL AIRPORT

ONE OF THE SPECIAL SERVICES of the Weather Bureau is the issuing of frost warnings during the growing season. In the Middle Atlantic states orchardists are most concerned with frost during the spring months. This period usually begins late in March and continues into May.

At the Washington National Airport office of the Weather Bureau, frost warnings for the following night are generally included in the regular agricultural forecasts prepared for distribution during the early morning hours. Hence, the forecaster uses the synoptic weather reports, both surface and aloft, that are made approximately 36 hours in advance of the time of the expected frost. Later reports during the day may then be used to modify the frost forecast, and the expected temperature range over the fruit-growing area. Further refinements for individual orchard locations require local studies and observations.

The purpose of the study described here was to show the general weather conditions associated with frost in the fruit-growing areas of Virginia, western Maryland, and eastern West Virginia during spring. In addition, data have been tabulated to show the frequency of frost mornings, the duration of frost periods, the wind speed at sunrise, and the temperatures on frost mornings.

A frost morning is defined as one for which a minimum shelter temperature of 32° F. or less was reported from any one of the following weather reporting stations: Washington, D. C.; Martinsburg, West Virginia; Front Royal, Virginia; and Gordonsville, Virginia. Since the zone of frost damage to fruit is several feet above ground, shelter temperatures gave a satisfactory standard. This is in contrast to the very low ground temperatures observed in cranberry bogs on frost mornings.

Frost may be of the radiation type, with little or no air movement, or of the wind type, in which there is appreciable air movement. It has been suggested that at sunrise, the usual time of the minimum temperature, a wind speed of five miles per hour may be considered the upper limit for radiation frost.

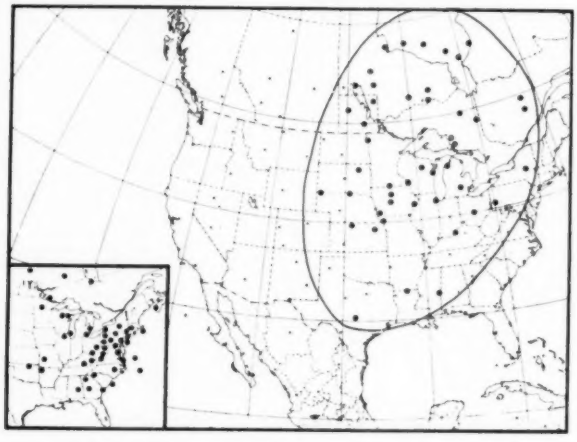


Fig. 1 (left). Location of anticyclones at 0630 GMT the day before frost occurred in the Middle Atlantic states during spring. The inset shows the location of anticyclones at 1230 GMT on frost mornings.

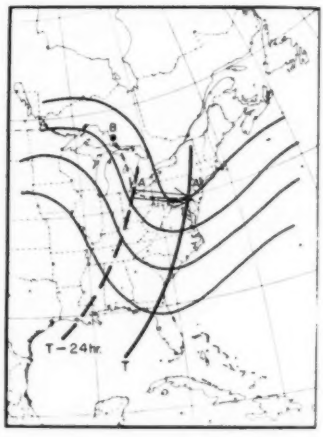


Fig. 2 (right). Contours at the 850-mb level in a typical frost situation. A — A′ represents the 24-hour movement of the contours. Point B is the source point of the cold air expected over the Middle Atlantic states the next morning.

Summary of Data

Four years of data (1947-1950) from March 27th to May 14th have been included in the study. During this four-year period of 196 days, frost (as defined above) occurred on 46 mornings, ranging from six cases in 1948 to 15 in 1950.

Most occurrences of frost are of only one-day duration, but in a few cases of slow-moving anticyclones frost has persisted for as long as five days. There were 15 occasions of frost lasting only one day, four of two days, none of three days, two of four days, and three of five days duration. The wind observations taken at Washington National Airport at sunrise on frost mornings were used to determine the frequency of radiation frost and of wind frost. As may be seen from the following table, radiation frost (with winds up to five miles an hour) occurred about one third of the time. The usual orchard heating methods, however, may give some protection against frost up to wind speeds of 10 miles per hour, which occurred over three fourths of the time. The number of days for each case are shown:

Wind speed (m.p.h.)	1947	1948	1949	1950	*Total*	%
Up to 5	7	1	5	3	16	35
6 to 10	2	4	9	5	20	43
Above 10	2	1	0	7	10	22

Synoptic Conditions When Frost Occurred

It is well known that most frost periods occur when a cold continental air mass invades the Middle Atlantic states. Fig. 1 shows the location of centers of anticyclones on the 0630 GMT map of the day preceding frost. Most centers were located to the northwest of the Middle Atlantic states from the Great Lakes and the upper Mississippi Valley to Hudson Bay. In cases where the center of highest pressure was south of the Middle Atlantic states, a pronounced ridge extended from the center north to the region of the upper Great Lakes or Hudson Bay. The central pressure in the anticyclones associated with frost ranged from 1015 to 1045 millibars, with the greatest number in the range of 1025-1030 millibars, as follows:

1015-20	2	1030-35	12
1020-25	8	1035-40	6
1025-30	17	1040-45	1

The location of high centers on frost mornings is also shown in Fig. 1. The major

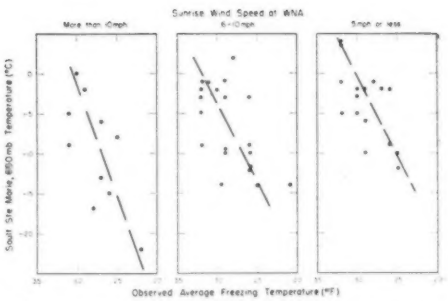


Fig. 3. The average freezing temperature on frost mornings and the 850-mb temperature at Sault Ste. Marie, Michigan, the previous morning, as a function of the sunrise surface wind speed at Washington National Airport on frost mornings.

portion of the centers are over or near the Middle Atlantic states. However, in some cases the cold air centers remained well west of the fruit-growing area, indicating several days of frost danger.

In addition to there being an anticyclone to the northwest of the region, the air within the anticyclone must be sufficiently cool for freezing temperatures to develop by nocturnal radiation or cold air advection. Since the anticyclone centers on the day before frost were generally in the Great Lakes region or farther northwest, the 10 p.m. radiosonde ascent at Sault Ste. Marie, Michigan, was used to estimate the degree of coolness of the air mass. The temperature recorded at the 850-mb level (5,000 feet) was found to be most valuable and convenient for this purpose.

A tabulation of the temperatures at this level at the "Soo" on nights before frost suggested that a reading of 0° C. was about the critical value for frost occurrence. The frequency distribution of the 850-mb temperature in degrees Centigrade on frost mornings is:

−25° to −20°	1	−10° to −5°	11
−20° to −15°	2	−5° to 0°	17
−15° to −10°	12	0° to +5°	3

In three cases of slow-moving anticyclones, frost occurred when the temperature at the 850-mb level at the Soo climbed to over 0° C. However, in these three cases frost had occurred the previous night in the fruit belt, preceded by 0° C. temperature or less at the Soo.

Further, the air flow at the 850-mb level must be sufficient to force the cold air into the Middle Atlantic states during the forecast period. This can be determined by using the past 12- and 24-hour displacement and height changes of the trough and ridge pattern at 850 millibars. Fig. 2 illustrates a case in which the movement of the pressure pattern would indicate cold air advection from the Great Lakes to the Middle Atlantic states. An estimate of the source of the cold air can be made by finding point *A* (pattern advection point). Then locate the source point *B* by using the wind speed indicated upstream from point *A*.

No frost occurred during this four-year period without the above conditions being observed. However, in 12 cases the necessary conditions prevailed but frost did not occur. In four of these cases, temperatures over the area remained in the range of 33° to 37° F. during the night. In five cases rapid changes in the circulation patterns changed the expected northwest flow of the cold air. In three instances, a wave developed southwest of the region and spread cloudiness and rain.

Temperatures on Frost Mornings

The minimum temperatures observed at the various reporting stations in the fruit belt on radiation frost mornings may vary as much as 10 to 20 degrees. For example, on April 15, 1950, Washington reported 32° F., Martinsburg 28° F., and Gordonsville 17° F. Usually Gordonsville reports the lowest temperatures, especially on radiation frost mornings. On frost mornings with winds of 15 m.p.h. or more, variation of the temperature is usually five degrees or less.

Minimum temperature readings on frost mornings, when skies are generally clear, are related to the air-mass temperature and the amount of nocturnal radiational cooling. The expected air-mass temperature on such mornings may be estimated from the 850-mb level temperature data taken at Sault Ste. Marie on the previous day. During the night, with wind speeds of more than five miles per hour, the mixing of the lower layers of the air will maintain higher ground temperatures than on nights of very light or calm winds. On radiation frost mornings, temperatures average about two degrees lower than on wind frost mornings. In Fig. 3, these two factors, the previous day's 850-mb temperature over the Soo and the sunrise wind speed at Washington, are related.

Criteria for Frost

In spring, frost in the Middle Atlantic states is likely when:

a. A high pressure center or ridge is located in the area outlined in Fig. 1.

b. Temperature at the 850-mb level at the Soo is 0° C. or less. (Exception: Soo temperatures may be higher and frost still occur if a slow-moving high cell in the Middle Atlantic states gave frost the previous morning.)

c. A source of 850-mb air trajectory is northwest of the Middle Atlantic states and is located in the cold air.

Testing the Criteria in 1951

During the spring of 1951, the information contained in this study was examined by forecasters at Washington National Airport, and the results are supplied here by Conrad P. Mook, research forecaster: Daily record was kept of the position of the high, the 850-mb temperature at Sault Ste. Marie, and the forecast 850-mb trajectory.

Four frosts occurred after March 19th, when the checking was begun, but in two of these only two of the necessary conditions were met. In one, an 850-mb temperature of −17° C. at the Soo made frost likely regardless of the predicted southwest trajectory.

In April, three frosts occurred subsequent to the occurrence of the three necessary conditions, with no frosts reported when the conditions were not met. During May, through the 14th, the three conditions were not found together at any time, and no frosts were reported.

The Washington forecasters consider this study to be a useful aid for the issuance of frost warnings for the Middle Atlantic states.

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The author is now at the U.S. Weather Bureau District Forecast Center, Chicago, Illinois.

THE MILD AND SNOWY WINTER OF 1951-52

ALTHOUGH among the mildest winters on record for the nation as a whole, the winter of 1951-52 was one of the snowiest of recent years in many diverse regions. Though winter made an unusually early appearance in the first week of November, with several cold spells in mid-December, polar air from the arctic was remarkably absent during most of January and February. Canadian anticyclones stayed on their side of the border, and mild, moist air from the Pacific held sway across the nation.

Temperatures were well above normal throughout the winter season for the eastern two thirds of the country; only in the plateau region, where the Great Basin high was an important feature, did the mercury remain below seasonal levels for any considerable time. But there was plenty of moisture to bring heavy snows to many parts of the country. The mountains of both California and Colorado had record totals; there was a persistent, deep snowcover in the upper plains centered in South Dakota; and in northern New York and New England it was a snowy winter of the old-fashioned type.

From preliminary reports, it appears that the lowest temperatures of the winter occurred quite early. Taylor Park, Colorado, a traditionally cold pocket in the mountains, reported −41° F. on December 7th, and the same mark was reached at Bondurant, Wyoming, two days later. Both of these low readings came from the influence of a large Great Basin high that built up in Idaho and Utah to a pressure of 1047 mb (30.92 inches), the highest barometer reading of the winter in the United States, according to map reports. See WEATHERWISE, February, 1952, for an account of December's weather.

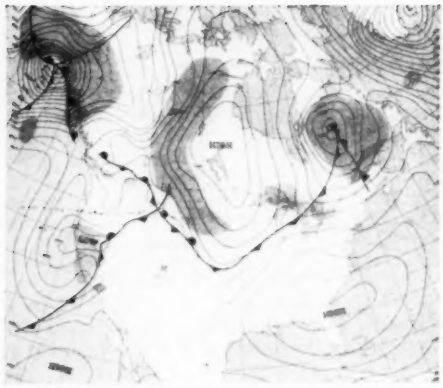
The first days of January continued the regime in force at the close of December. The main feature of the upper-air circulation was the development of two troughs. The first took form over the eastern states on the 6th. A secondary disturbance generated in the trough over the Carolinas developed into a major storm, and was centered the next day between New York and Bermuda with the central pressure down to 980 mb (29.03 inches). In team with a high over Quebec, it caused gales on the Middle Atlantic and New England coasts.

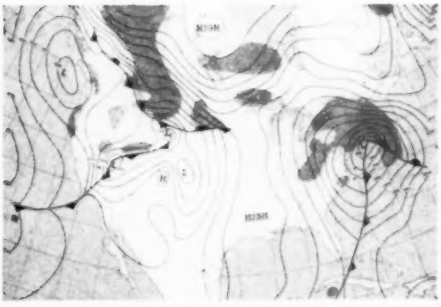
The rest of the country, with the exception of the Far West, experienced a minimum of storminess. The second upper-air trough extended from Hudson Bay westward to the Pacific Ocean off Oregon. This initiated a flow of west and southwest winds over most of the United States and effectively shut out the influence of the arctic from all but the border states west of Minnesota, a condition that was to be the dominant feature of mid-winter weather.

To the west of the Rockies, the southwesterly flow brought an entirely different situation, for a major surface and upper-air trough of low pressure encouraged a series of Aleutian depressions to move southeastward, subjecting the coastal area to a battering of gales, record rains, and floods, and unleashing storms of wind and snow in the mountains, storms that had been unequaled since 1892.

Sierra Snows. The first snowstorm of the winter occurred on October 24th at the Central Sierra Snow Laboratory at Soda Springs (elevation 6,752 feet), located near the famous Donner Pass, whose wintry moods have plagued pioneer wagon trains and modern streamliners alike. Snowcover was continuous thereafter, reaching a maximum depth of 246 inches. The following record of the major snowstorms of the 1951-1952 season was reported to WEATHERWISE by William H. Parrott, project su-

Donner Summit Lodge, a mile below the summit, on January 26, 1952. Adjacent to the lodge the snow reached a depth of 224 inches in February. Before snow fell or was shoveled off the lodge roof, patrons were able to ski and toboggan from the roof to the roadway. Photograph by R. W. Gerdel.





TOP: A Sierra snow type map of January 12, 1952, at 1:30 p.m. EST. The cold front has just passed the crest of the mountains, but the elongated low pressure center extends westward and maintains a flow of moist air, accounting for the heavy snowfall and unusual rains. Another deep low is in the Gulf of Alaska, and will move southward and cause heavy rains in the Los Angeles district on the 15th.

BOTTOM: A New England snow type map of February 17, 1952, at 1:30 p.m. EST. Precipitation has been falling in southern New England for 12 hours and has reached central Maine at map time. Note the east-west orientation of the isobars over New England with high pressure over eastern Canada, a typical synoptic situation accompanying heavy snow in New England. Twenty-four hours later the storm was centered south of Nova Scotia with a central pressure of 975 mb.

pervisor of the Snow Laboratory for the Corps of Engineers:

Date	*New Snow*	*Water Equivalent*	*Total Snowcover*
Oct. 24-25	31	3.75	30
Nov. 19-22	57	5.97	66
Dec. 1-6	67.3	9.95	84
Dec. 24-31	85.9	10.45	133
Jan. 10-16	152.4	13.95	195
Jan. 24-26	41.4	4.69	199
Feb. 11-12	23.6	2.17	184
Feb. 16-22	81.9	6.40	223

New snowfall for the season through February 22nd amounted to 630.3 inches, with a water equivalent of 76.02 inches. Records have been maintained in the vicinity of Soda Springs since 1904, and this appears to have been the snowiest winter on record. The all-time record for a California location for an entire winter apparently belongs to the now-abandoned survey site at Tamarack, Alpine County (8,000 feet), where the winter of 1906-07 brought a total of 884 inches and a maximum snowcover of 348 inches that year.

The highlight of the current snow season was the big storm of January 10-16, and the big day was January 12th, when 45 inches of new snow fell in 24 hours. This was the day that the crack streamliner, City of San Francisco, stalled in the snowdrifts at Crystal Lake, near Soda Springs. Its occupants were cut off from the rest of the world for three days until a rescue team, with members of the Snow Laboratory playing a leading role, was able to break through and remove the travelers to the Donner Summit inn. This marked the first time since the exceptionally snowy season of 1892 that the tracks of the Southern Pacific Company through Donner Pass had been blocked for any considerable period.

Los Angeles Flood. The same series of storms that gave the Sierras their heaviest snows treated the coastal regions to a lashing of wind and very heavy rains. Precipitation at San Francisco amounted to 7.92 inches in December, and 10.69 inches in January, half of which fell from the 10th to the 16th. The accumulated rainfall from July, 1951, through January, 1952, was the greatest since 1892, according to a report sent to WEATHERWISE by E. L. Felton, meteorologist in charge of the San Francisco Weather Bureau.

Farther south, the same storms produced Los Angeles rainfall of 5.80 inches in December, 10.03 inches in January (the third greatest for that month on record). With the ground already well soaked, storms of 3.39 and 3.98 inches, on January 15-16 and 17-18, respectively, set the stage for a flood of major proportions. The Los Angeles basin, with a semicircle of hills and mountains to the north and east, is very susceptible to moisture-laden southwesterly winds. The following figures were supplied to WEATHERWISE by A. K. Showalter, of the Los Angeles Airport Weather Bureau:

Station	*Jan. 15-16*	*Jan. 17-18*
City Office	3.39	3.98
North Hollywood	6.48	4.83
Glendale	5.42	5.02
Griffith Park	5.86	5.30
Burbank (Riverside Drive)	7.26	5.56
UCLA, Westwood	4.31	3.88
L.A. City College	4.42	4.23

At mountain stations maintained by the Los Angeles County Flood Control District, some very high monthly figures were reported. Camp Baldy in the San Gabriel Mountains had 14.14 inches in December and 14.31 inches in January.

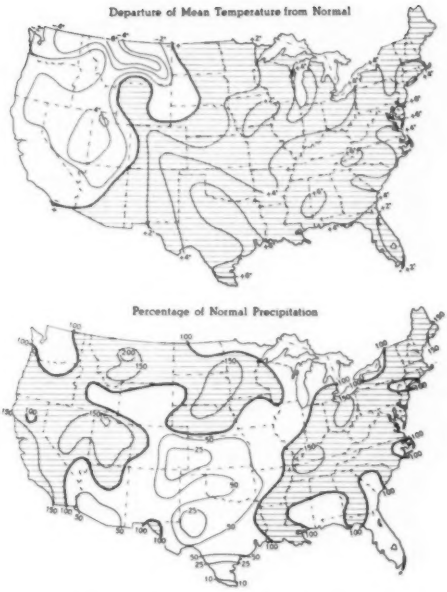
Rocky Oaks Ranch in the Santa Monica mountains reported a January total of 21.68 inches, with 8.29 inches falling in one day, the 15-16th. Even in desert locations inland, heavy falls were measured, such as at Muntz Ranch, five miles east of Fairmont, with 7.67 inches in January.

The flood waters that filled every canyon resulted in damage estimated at five million dollars; and 21 deaths were attributed to the storm. Much of the flooding was caused by the poor condition of drainage ditches that had been allowed to fill with debris since the last major flood of 1943, and by the blocking of natural drainage in postwar construction projects. Many homes and garages in new developments found their drainage systems inadequate and were inundated by floods of water and mud.

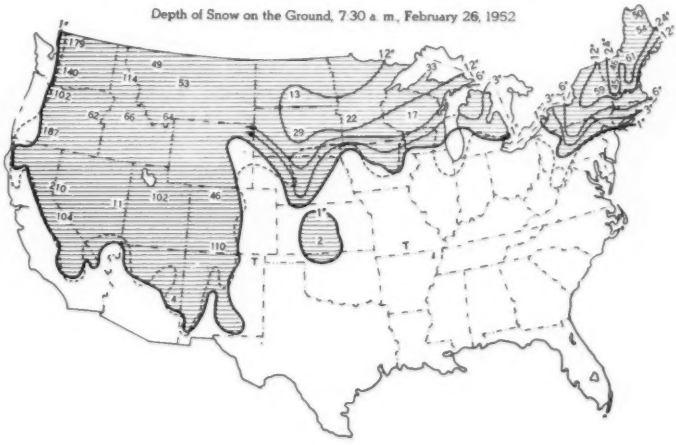
High index of westerly circulation persisted after the middle of the month with lows moving across the northern United States. Cold air was confined to the northern border, and it was unseasonably warm in the South and Middle West. The week ending January 22nd in Texas was reported to be the warmest ever known in January, with a plus 21° departure from normal registered at Austin. At Topeka, Kansas, it was the second warmest seven-day period for January of record. On the 19th the following maxima were reported: Laredo, Texas, 88°; Ft. Smith, Arkansas, 81°; St. Louis, 75°; and Jackson, Michigan, 63°.

An abrupt change to low index circulation took place on the 19th and 20th. A large high pressure area of great magnitude began to appear over the Yukon-Mackenzie area of Canada on the 17th, and pressure had built up to 31.18 inches on map reports of the 21st. At the same time a temperature of —72° was registered at Northway, Alaska. A clear channel was opened by a ridge that extended from the Arctic Ocean to the Gulf of Mexico, and down the eastern side of the ridge poured surges of arctic air as a deep low over the Hudson Bay area served as a pinwheel to encourage the flow. The mercury dropped to —33° at Minot, North Dakota, on the 22nd and to —31° at International Falls, Minnesota, on the 23rd, the coldest readings of midwinter; the zero line reached south of Chicago on the 24th.

The mean map of upper-air circulation for February reversed January, for now ridge conditions dominated the West and a trough took



U. S. Weather Bureau charts showing the departure from normal of the mean temperature, and the percentage of normal precipitation, for the winter months, December-February, 1951-52, based on preliminary telegraphic reports. The shaded areas are normal or above.



Compare this snowcover map with that for Christmas Day, 1951, on page 19 of *Weatherwise* for February. Depths in the Sierras and the Northeast have more than doubled, but in the Middle West the snow line has receded northward considerably. From the *Weekly Weather and Crop Bulletin*, courtesy USWB.

Snow in Maine during February accumulated to considerable depth. Here a shopper in Greenville uses a tunneled entrance to the local weather observer's store.

form off the Atlantic Coast. Neither of these, however, was well developed, and this gave a key to the month's circulation pattern. It was largely zonal, with westerlies prevailing. Pacific air flowed around the Great Basin high and into the central United States. This was well illustrated by the long run of days at Bismarck, North Dakota, from January 31st to February 21st, without a below-zero reading.

Not until the northeaster of February 17-18 on the Atlantic Coast did an important outbreak of polar air cross the border. In fact, the circulation index, on which the mean upper-air maps are based, reached a very low ebb about the middle of the month as a blocking high in mid-Atlantic built up from the Azores region, extended northwestward, and joined isobars with a persistent high over Baffin Land and Greenland. All storm movements were slowed and shunted somewhat south of normal. Hence a series of disturbances that originated in the Gulf of Mexico brought unpleasant weather to Florida resorts and later harried the New England coast when their normal northeastward progress was delayed by the blocking high.

New England's Snowy February. In recent years, New England has failed to add to its reputation for old-fashioned winters, much to the chagrin of weather fans and winter sports enthusiasts. Not since the season of 1947-48 has snowfall approached normal, and most of the winter months have been dominated by an inflow of mild air from the Atlantic. But February, 1952, took its place among the snowiest and windiest in New England annals.

The main features of the month were two notable northeasters. The storm of February 17-18, which developed at the southern end of the north-south trough in a complex low pressure area over the Gulf of Mexico, moved northeastward and was centered off the New Jersey coast on the morning of the 17th with a low pressure of 29.68 inches at Easton, Maryland; but by 0330 the next morning it passed east of Nantucket Island, Massachusetts, with the lowest reading at 28.79 inches. A gust of wind about that time reached 62 m.p.h., and sustained winds of 52 m.p.h. from the north continued all morning. During the gales two tankers, the **Pendleton** and the **Fort Mercer,** were caught in the mountainous seas and broken in two.

The intensification of this storm is graphically illustrated by the increased rainfall as the center moved up the coast. New York City received 1.10 inches, Block Island, 1.76 inches, Nantucket, 2.48 inches, and Portland, 3.25 inches. In northern New England it was all snow, with new falls of over two feet.

The most spectacular storm of the month hit southeastern Massachusetts on the 27th and 28th of February. It has been called the Cape Cod blizzard, although one of the essential ingredients of a true blizzard, zero temperatures, was missing. Nevertheless, it was the worst Cape Cod snowstorm in half a century. It also was born in the Gulf of Mexico, moving off the South Atlantic coast, apparently headed well out to sea. Forecasters along the Middle Atlantic seaboard were in a quandary, confronted with the problem as to just how far inland the snow might extend. As the center sped up the coast, snow just missed Washington, gave Atlantic City a brief fall, then spread a mantle of white over eastern Long Island and the immediate coastal areas of southeastern New England. Boston received only six inches, but at Hyannis on the Cape it was 14 inches, on Martha's Vineyard, 16 inches, and on Nantucket, 20 inches, the heaviest snow in the 63-year history of the Weather Bureau there. The total snowfall for the period February 18th-March 1st was 42.6 inches, according to Don K. Halligan, USWB. During the storm of the 28th, sustained winds on Nantucket reached 61 miles per hour, with gusts to 72 miles per hour. The island was isolated except for radio communication.

The center of the storm remained well off the coast, and there was a ship barometric report of 28.02 inches. Wind damaged Cape Cod shore installations and piled loose snow into mountainous drifts, but the worst feature was the leveling of electric lines, which cut off power for heating and cooking in 10,000 homes, again emphasizing the disruption that a single storm can cause in the intricacies of modern life. D. M. L.

COMPENDIUM OF METEOROLOGY

American Meteorological Society, Boston, 1952. 1,334 pages. $12.50.

IT WOULD BE almost impossible for one to keep abreast of all the literature that is being published in meteorology these days. The American Meteorological Society has come to the rescue by arranging for outstanding people in the field, each with a background of specialized knowledge, to inventory their specialties.

In 1948, the Geophysics Research Division of the Air Force Cambridge Research Center invited the AMS to organize a book which would summarize and appraise the most important developments in the various phases of meteorology. In 1949, 102 authors were commissioned to write the 108 articles that are contained in the **Compendium of Meteorology.** In some cases more than one author contributed to a subject, thus lending varied points of view.

This momentous volume is divided into 25 sections arranged in logical sequence. Starting with the composition of the atmosphere, the whole gamut of topics is presented from the physical state of the atmosphere to dynamics, forecasting, and climatology, and through such specialized subjects as radar meteorology and microseisms.

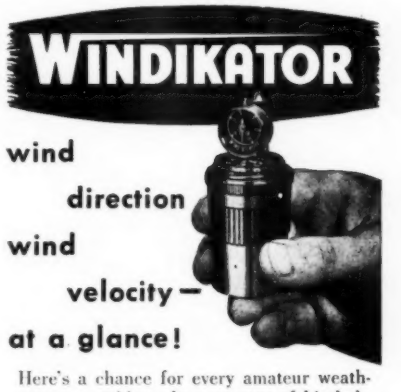
The first section presents a review of the factual knowledge of the composition of the atmosphere and points out how this knowledge is still inadequate. Following is a section devoted to the problems of radiation with emphasis on such subjects as the details of solar radiation, long-wave radiation, and instrumentation.

The processes by which precipitation can cause the separation of electrical charges are reviewed, together with a discussion of the electrification of aircraft when flying through ice clouds and snow, in one of the papers in the section on atmospheric electricity. This section leads directly to the one on cloud physics. Here the initial paper presents a broad survey of the problems associated with condensation nuclei, the growth of condensation products, and the formation of precipitation elements. It is followed by several papers on more specialized topics that have received considerable attention in recent years. One of these discusses problems relating to the control of the weather. Another deals with the relation of artificial cloud modification to the production of precipitation. In contrast with many other areas of meteorology, certain aspects of this problem lend themselves to the techniques of the experimental physicist.

In the section on cosmical meteorology, the possible relationship between variations in solar energy and anomalous weather changes is discussed. Because of the present lack of information in this field, it is impossible to prove or disprove the effective influence of irregular solar variation on the fluctuations of the global weather patterns. However, the present position of knowledge is appraised and conclusions are presented.

Sections on the dynamics of the atmosphere, the general circulation, and secondary circulation follow. The section on local circulations contains readable articles on such topics as tornadoes and thunderstorms. In the latter, the new theories developed by the thunderstorm projects are discussed and new results presented.

In the section on observations and analysis, the authors review and evaluate in some detail the past and present techniques of weather analysis. A discussion is presented of the various types of weather maps and charts and how they are used together to arrive at the weather analysis. This leads to the inevitable problem of weather forecasting, the topic of the next section. Here, a broad review of the progress in the science of forecasting is presented. The nature of the problem, the merits and limitations of forecasting techniques and aids, and recommendations for the improvement of weather forecasting are discussed. Following are more detailed and specialized papers on short-range



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forecasting, objective weather forecasting techniques, and several most absorbing papers on extended-range forecasting.

The fields of tropical, polar, and maritime meteorology are also reviewed. The various phases of climatology are presented, not exhaustively, but rather in an effort to give the subject a physical and dynamical point of view. Other fields treated are: hydrometeorology, with a review of the physical basis for forecasting maximum precipitation; river forecasting and run-off problems; biological and chemical meteorology, which deal with the atmosphere as the medium for the dispersal of organisms and the effect of weather changes on the human body and behavior; and atmospheric pollution, which has become of such tremendous importance in recent years.

The section on clouds, fog, and aircraft icing presents articles reviewing the present state of cloud classification, pointing out old ideas that are still valid as well as new ones. Also contained here is an article on the use of clouds in forecasting the weather.

The more recent developments in meteorological instruments, including new radio instruments, automatic weather stations, and ceilometers, are presented in some detail. Radio meteorology, one of the newer branches of the field, is covered, with a discussion of the background, theory, and use of radar in weather forecasting and storm detection. The other end of the radio spectrum is also dealt with in an article on sferics. Finally, several articles present the theory and practical application of microseisms to forecasting.

It is difficult to review a book of such tremendous scope as the **Compendium** in such a limited space. An attempt has been made to present a brief survey of some of the contents of the book in order to give an idea as to the type of material contained therein.

What makes this volume so important is that each article critically reviews and presents in concise form the present state of knowledge in one of the fields of meteorology, and offers at its conclusion suggestions for further study as well as a comprehensive bibliography. To the professional meteorologist, this book is indispensable. To the layman and weather amateur, the many extremely readable articles are most interesting and informative.

H. NEWSTEIN
U. S. Weather Bureau
Philadelphia, Pa.

NEW BOOKS RECEIVED

NORTH OF THE CIRCLE. *Frank Illingworth*, 1951, *Philosophical Library*. 254 pages. $4.75.

All geographical areas of the Arctic are treated in separate chapters. Weathermen will be interested in the sections, "Home of the Weather" and "The Arctic Is Melting." An interesting account of the attempts of the Germans to establish arctic weather stations in World War II is included.

GREAT SHIPWRECKS AND CASTAWAYS, edited by *Charles Neider*, 1952, *Harper*. 238 pages. $3.00.

A collection of firsthand accounts of many thrilling and gruesome experiences of those who have been caught by nature's fury. The volume contains several good reports of hurricanes and winter gales on the Atlantic.

ATMOSPHERIC POLLUTION

The very important question of atmospheric pollution is the subject of the latest issue of **Meteorological Monographs**, published by the American Meteorological Society. The current volume is the outcome of the panel discussion that took place on this subject at the 30th anniversary meeting of the AMS in St. Louis. Twelve experts, under the editorship of Dr. E. Wendell Hewson, have surveyed their specialties and written up-to-date information, making a collection of material unavailable in one volume elsewhere. **On Atmospheric Pollution** may be purchased through the AMS; price is $2.50 to members, $4.50 to others.

The following table of contents will illustrate the complete coverage given the subject of air pollution:

Enforcement principles and standards, by J. H. Carter

Meteorology applied to air pollution abatement, by C. A. Gosline

Meteorological influences and their application to control at the source, by E. W. Hewson

Climatology and its part in pollution, by H. Landsberg

Diffusion of stack gases in very stable atmospheres, by M. L. Barad

The statistical theory of diffusion by turbulent eddies, by G. W. Brier

Instruments for air pollution measurement, by W. C. L. Hemeon

Microclimate factors in smoke pollution from tall stacks, by P. H. Lowry

Ground-level measurements of oil-fog emitted from a hundred-meter chimney, by P. H. Lowry, D. A. Mazzarella, and M. E. Smith

Gustiness profiles in the lower layers of the atmosphere, by H. F. Poppendiek

Air-tunnel studies of diffusion in urban areas, by H. Rouse

Analyzing winds for frequency and duration, by R. H. Sherlock

The forecasting of micrometeorological variables, by M. E. Smith

Among these, of particular interest to the layman with an amateur's interest in meteorology would be the second, third, fourth, seventh, eighth, and last articles.

D. M. L.

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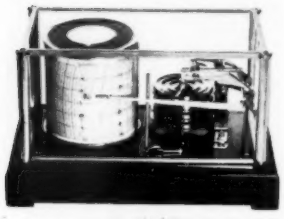

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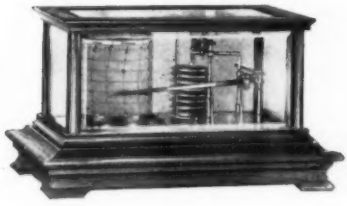

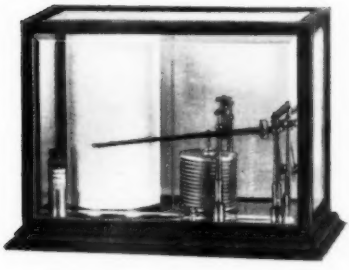

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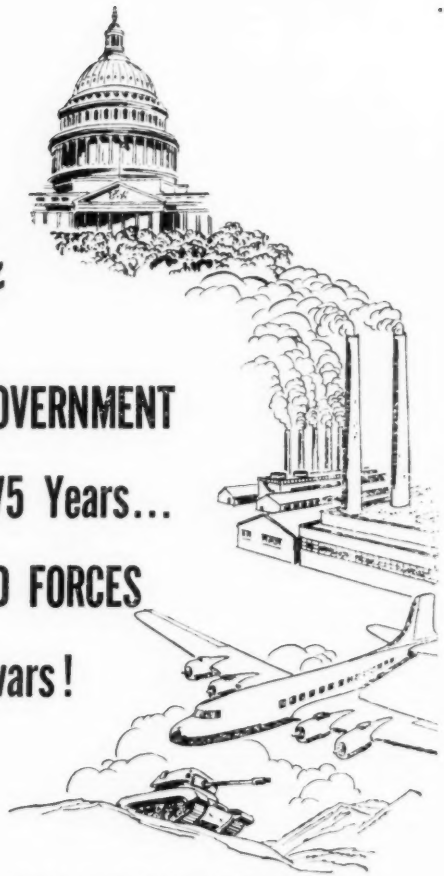

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